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Mailing Date: October 9, 1998

Cover Illustration: Atlantic Kemp's ridley sea turtle (*Lepidochelys kempi*) taken from pound net in Pocomoke River, Somerset County Maryland on 18 June 1997. Photograph curtesy of Dr. Joyce J. Evans, Cooperative Oxford Laboratory, Oxford, Maryland.

Biology of the Giant Resin Bee, *Megachile sculpturalis* Smith, a Conspicuous New Immigrant in Maryland

Suzanne W. T. Batra

ABSTRACT.- Both sexes of *Megachile sculpturalis*, a large east Asian solitary bee, were found on privet flowers at Beltsville, Maryland, in July, 1997. It was intercepted at ports in 1968 and 1976, and was first recorded living in the USA, in North Carolina, in 1994. The preferred pollen host of this bee is kudzu, *Pueraria lobata,* a native of eastern Asia. It makes cells out of resin in holes in wood and in hollow stems. It is expected to extend its range throughout the mid-Atlantic and southeastern United States. It may have some value as a managed pollinator of legumes, other crops, and ornamentals that bloom in summer.

Introduction

Megachile (*Callomegachile*) *sculpturalis* (Hymenoptera: Megachilidae) is native to eastern Asia, ranging from Szechuan, S. China (30°N) to Taiwan (22 - 25°N), and throughout Japan, including Hokkaido (43°N). It is a large, handsome insect, and it does not resemble any native North American bee. Females are 22 - 27 mm long; longer than most native bees, including bumble bees and carpenter bees, but they are more slender than these latter two. Male *M. sculpturalis* are 14 - 19 mm long. Both sexes have dusky (fuscous) wings, which are often partly extended while these bees are foraging on flowers, forming a "V" shape. Both sexes have black integuments and large heads (female heads to 6.5 mm wide, with large, powerful mandibles). Their thoraces (metasomas) and first abdominal terga are densely covered with rust-brown (rufous), velvety hair. Males have an integumental prong at the base of each front leg; rufous hair beneath their heads, at the bases of their antennae, and as a pale fringe (mustache) on the clypeus. Females have abdominal scopae of stiff, black and dark brown hair, with some rufous hair anteriorly. Both sexes may have narrow, lateral apical bands of pale hair on the second and third abdominal terga.

Discovery in Maryland

During a drought, on July 17 and 18, 1997, I collected a male and 2 females of *M. sculpturalis*, gathering nectar from flowers of privet (*Ligustrum vulgare*) at the Bee Research Laboratory, Beltsville Agricultural Research Center, Prince George's County, Maryland. In 1988, I had observed this bee at Matsue, Shimane Prefecture, Japan; thus I recognized it, and compared the Maryland bees to specimens in my reference collection. When I contacted Dr. Y. Maeta of Shimane University about this find, he informed me (*in litt.*, 7/23/1997) that *M. sculpturalis* was also collected in North Carolina. This bee was first found in North America in June, 1994, on flowers of ornamental Asian golden rain trees (*Koelreuteria paniculata*) growing on the campus of North Carolina State University, Raleigh; by 1996, it was found elsewhere in North Carolina (Mangum and Brooks 1997); subsequently, it was collected in Georgia, South Carolina, and Virginia (Mangum, pers. comm. 1998).

This bee may have come to Maryland from North Carolina on the southwesterly winds that prevail during summer, when it is active; or it may have been transported in vehicles. It is also possible that *M. sculpturalis* arrived independently in cargo at the port of Baltimore, which is near Beltsville. I had identified two specimens of *M. sculpturalis* that had been intercepted at U.S. ports in 1968 and 1976, in cargo from Japan. Just one inseminated female bee could establish an immigrant population.

Intercepted Alien Bees

Fewer than 10 adventive bee species have become established in the continental United States; rather

few considering the vast quantity of goods that are imported. While I identified bees for the U.S.D.A. Systematic Entomology Laboratory from 1974 to 1985, I recorded the genera, origins, modes of transport, and commodities on which specimens were found at ports and border checkpoints. *Apis mellifera* was the most commonly intercepted bee, but many other species in 28 genera were also captured. Thirteen of these genera included species of twig-, wood-, and cavity-nesters; the rest of the bees nested underground. Most bees came from the Western Hemisphere (especially Mexico), and most were found in shipments of fruits, vegetables, candies, or sugar. Others were loose in baggage and cargo containers; loose in vehicles; inside nests in wooden crates, logs and posts; and sleeping in fresh-cut, chilled flowers.

Hosts of *M. sculpturalis*

In Japan, the preferred source of pollen for nesting females is kuzu (= kudzu, *Pueraria lobata*; Fabaceae), and the period of adult activity coincides with the bloom of this plant. At Matsue, Japan, I found females foraging for pollen on kudzu, but males visited kumquat (*Fortunella margarita*) flowers for nectar. Iwata (1933) and Sasaki and Maeta (1994) confirm its preference for kudzu flowers, but other hosts are visited, including beans, *Phaseolus vulgaris*, and cowpeas *Vigna sinensis*; also *Millettia japonica*, *Dumbaria villosa* and *Lespedeza* spp. In China, it forages on crape myrtle, *Lagerstroemia indica* (Piel 1933a).

In North America, *M. sculpturalis* forages on catalpa (*Catalpa speciosa*) and sourwood (*Oxydendron arboreum*) trees (Mangum, pers. comm. 1998). It also may be expected to enhance the invasive spread of kudzu by setting its seed, although Mangum (pers. comm. 1998) did not find it on kudzu. This weed blooms as far north as Maryland. Although beans and cowpeas are self-pollinated, visits from *M. sculpturalis* may enhance their yields. Based on its native Asian range, *M. sculpturalis* may be expected to inhabit the humid, subtropical to temperate climates of the southeastern and mid-Atlantic United States, from eastern Texas to Florida, north to southern New England.

Nests of *M. sculpturalis*

In Asia, *M. sculpturalis* builds its nests in a variety of holes. It prefers to nest in holes in shady places, 0.5 - 5.0 m above the ground, and sheltered from rain. It nests in abandoned burrows made by carpenter bees in wood (Piel 1933a), thus resembling *M. monticola*, a related Asian species (Piel 1930). In North Carolina, *M. sculpturalis* was seen near buildings with holes that had been made by native carpenter bees (Mangum and Brooks 1997). It will also use empty burrows in adobe made by other Hymenoptera, hollow bamboo internodes (Iwata 1933), and other large, dry, hollow, horizontal stems (Sasaki 1978). Nests consist of a series of brood cells made of plant resin, embedded in a matrix of resin mixed with a small amount of wood dust, bits of wood, and mud. The space between the nest entrance and distal brood cells is stuffed with debris (such as shreds of rotten wood, bark, straw, paper, mud, spiders' silk, small nails, rubber, wool, cotton, cork, and paraffin). The completed nest is sealed with mud, collected from damp soil (Iwata 1933, Piel 1933b). The number of cells per nest varies according to the size of the holes; a female makes a total of about 10 cells per nest; and one bee required 26 days to complete 4 nests (Iwata 1933). A maximum of 36 eggs were laid in 5 nests during 36 days (Maeta, pers. comm. 1998). Resin for constructing brood cells and nests is collected from conifers (Iwata 1933), and maple gum also is used (Piel 1933a); thus, this bee may be popularly named the "giant resin bee," as suggested by Mangum (pers. comm. 1998).

In Japan, *M. sculpturalis* hibernates as larvae inside cocoons in nests, pupates in May, and adults (males first) begin to emerge in late June. Females make nests from mid-July to mid-September (Iwata 1933). Males stay near nests, where they fight for access to females; they rub the compound eyes of females with their fore-tarsi during courtship (Sasaki 1978). Some bees may not break hibernation in March, but continue their diapause, to emerge the following year (Sasaki and Maeta 1994). Bees with such a long diapause are well adapted to survive transoceanic voyages, while dormant in their cells in holes in wooden

crates, lumber, and other objects. This large, beautiful bee is easy to maintain and observe (Sasaki 1978). It could be a good subject for research on insect behavior, and it may prove useful as a managed pollinator of large-flowered legumes, other crops, and ornamental plants that bloom in mid- to late summer.

Acknowledgments

I thank Drs. Y. Maeta, W. A. Mangum, C. D. Michener, and R. W. Brooks for information about *M. sculpturalis* in North Carolina. The manuscript was improved by Y. Maeta, W. A. Mangum, and A. W. Norden.

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The Bridle Shiner (*Notropis bifrenatus*) in Northern Virginia: A Correction

Carl H. Ernst

The bridle shiner (*Notropis bifrenatus*) ranges from southern Maine and the Lake Ontario-St. Lawrence River watershed south to Virginia and the Neuse River drainage of North Carolina (Eddy and Underhill 1978, Page and Burr 1991), and, in spite of being relatively common in other parts of its range, is considered rare to uncommon in Virginia (Burkhead and Jenkins 1991). It is so rare that Burkhead and Jenkins (1991) and Jenkins and Burkhead (1994) recommended that it be named a Species of Special Concern by the Commonwealth of Virginia. Records from or prior to 1935 exist from the Potomac River drainages of Fairfax County (Jenkins and Burkhead, 1994). In 1995, Ernst et al. reported having collected *N. bifrenatus* at two sites in the Accotink Creek during a survey of the fishes of the Fort Belvoir Military Installation, Fairfax County. Voucher specimens were placed in the vertebrate collection of the Department of Biology, George Mason University, Fairfax, Virginia. Dr. Robert E. Jenkins, Roanoke College, Salem Virginia, questioned the identity of the shiners referred to *N. bifrenatus* by Ernst et al. (1995), and requested to examine the voucher specimens. After comparing them to the characters listed in Page and Burr (1991) and Jenkins and Burkhead (1994), Jenkins (pers. comm.) reidentified the fish as nonbreeding swallowtail shiners (*N. procne*). So, the continued presence of *N. bifrenatus* in the waterways of northern Virginia has still not been determined.

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Department of Biology
George Mason University
Fairfax, Virginia 22030-4444

New Records of the Milk Snake, *Lampropeltis triangulum*, From the Coastal Plain of the Delmarva Peninsula, With Comments on the Status of *L. t. temporalis*

William L. Grogan, Jr., and Don C. Forester

ABSTRACT.- The first records of the milk snake, *Lampropeltis triangulum*, are provided for the Coastal Plain of the Delmarva Peninsula from Dorchester, Kent and Wicomico Counties, Maryland, as well as new records from Cecil and Worcester Counties, Maryland and New Castle County, Delaware. Specimens from the southern portion of the peninsula are often brightly colored and exhibit morphological similarities to the scarlet kingsnake, *L. t. elapsoides*. Those from the extreme northern portion of the peninsula adjacent to the Piedmont more closely resemble the eastern milk snake, *L. t. triangulum*, but usually differ by having a light neck collar and blotches that extend to, or onto, their ventral scales. The milk snakes on the Coastal Plain of the Delmarva Peninsula have likely received only limited gene flow from mainland populations since the formation of the Chesapeake Bay 10,000-15,000 years ago. Populations of milk snakes on the mid-Atlantic Coastal Plain from southern New Jersey south throughout the Chesapeake Bay region are fairly uniform morphologically, in size, color pattern, and in habits. True intergradation with *L. t. triangulum* may occur only at the extreme northern and western portions of this form's range along the Fall Line. Therefore, we suggest that the mid-Atlantic Coastal Plain milk snake population should be recognized as the subspecies *L. t. temporalis*.

The systematic status of the milk snakes inhabiting the mid-Atlantic Coastal Plain from southern New Jersey to northeastern North Carolina is currently the subject of considerable interest and debate (e. g., Dongarra 1998). This form was originally described by Cope (1893) as *Ophibolus doliatus temporalis*, based on the holotype from Delaware. McCauley (1941) redescribed *Lampropeltis triangulum temporalis* and assigned museum specimens from Maryland, Delaware and New Jersey to this form. McCauley considered *L. t. temporalis* to inhabit the Coastal Plain in New Jersey and the Chesapeake Bay region, but stated that its southern limit was unknown. After a detailed reexamination of all available specimens of this complex, Conant (1943) concluded that *Lampropeltis elapsoides virginiana* Blanchard (1920), originally described from specimens from North Carolina and Virginia, was a synonym of *L. t. temporalis*. Conant also reported on specimens that he considered to be intergrades of *triangulum-temporalis* from along the Fall Line from southern New Jersey and southeastern Pennsylvania to northern Virginia, and intergrades of *temporalis-elapsoides* from central and eastern Virginia and central and eastern North Carolina. Subsequently, Conant (1958) considered *L. t. temporalis* a valid subspecies in the first edition of his eastern field guide.

Williams (1978, 1988) concluded that *L. t. temporalis* was a synonym of *L. t. triangulum*, and characterized the entire mid-Atlantic Coastal Plain population from southern New Jersey to northeastern Virginia as intergrades of the eastern milk snake, *L. t. triangulum*, and the scarlet kingsnake, *L. t. elapsoides*. He also noted that "specimens of *L. t. elapsoides* from southeastern Virginia and northeastern North Carolina reflect a trend toward the intergrade population." Conant (1975), and Conant and Collins (1991) apparently accepted Williams' (1978, 1988) interpretation of this form, but considered the entire population "in the lowlands and Piedmont from southern New Jersey to northeastern North Carolina" to be intergrades. Conant (1975) referred to this form as the "coastal plain milk snake" and illustrated a specimen with a light collar, yellowish ground color and reddish brown blotches that extend to, or nearly to, the ventral scales.

Williams (1978, 1988), Tobey (1985), and Ernst and Barbour (1989) referred to specimens from southeastern Virginia as *L. t. elapsoides*. Ernst and Barbour (1989) stated that the population found on the mid-Atlantic Coastal Plain was no longer recognized as a valid subspecies, but noted that individuals from that area are "highly prized in the pet trade" due to their striking color patterns. Based on numbers of ventrals, subcaudals and body blotches or bands, Mitchell (1994) considered all specimens from the Coastal Plain of Virginia to be intergrades of *L. t. triangulum* x *elapsoides*. Using similar meristic data, Palmer and

Braswell (1995) defined *L. t. elapsoides* in North Carolina as having 13 to 22 red body bands and a maximum total length of ca. 22" (564 mm). They regarded all 20 specimens known from northeastern North Carolina north of Pamlico Sound as intergrades, despite the fact that 5 of these had red bands completely encircling their bodies, whereas 60 of 65 specimens that they considered *L. t. elapsoides* from south of Pamlico Sound, had red bands completely encircling their bodies. In addition, the largest North Carolina specimens they examined from south of Pamlico Sound that they considered typical *elapsoides* were a male 564 mm and female 495 mm (total lengths). Their largest intergrade specimens from north of Pamlico Sound were both from Tyrrell County, a male 736 mm and female 654 mm in total length. It is interesting to note that their illustration of the midbody pattern of this large Tyrrell County female depicts its red blotches barely extending to some ventrals, but shows broad black pigmented bands that nearly reach the mid-venter, a pattern often seen in specimens from the Chesapeake Bay area.

Cox (1982) disagreed with Williams' (1978) interpretation of this form, considered *L. t. temporalis* a valid subspecies, and stated that *L. t. elapsoides* and *L. t. triangulum* did not intergrade. Similarly, Markel (1997) stated that "isolated populations and successful true breedings have resulted in the categorization of this snake as a possible subspecies." Markel and Bartlett (1995) remarked on the popularity of this form, which they defined as having an average total length of 21-35 inches (533-889 mm), a well defined light collar, 24-31 dorsal (body) blotches with at least the anterior most reaching the ventral scales, and a white to yellow ground color. They also stated that it is "far more distinctive in appearance than many of the Latin American races of milksnake."

Conant (1975) indicated that "The relationship of the Scarlet Kingsnake to the various races of the Milk Snake is highly unusual." He noted areas of sympatry in portions of Tennessee, Kentucky, and the southern Appalachians in which "the Scarlet Kingsnake and the Eastern Milk Snake occur together and maintain their identities." Similarly, Williams (1978, 1988) summarized the situation as follows "populations of *L. t. triangulum* and *L. t. elapsoides* genetically behave like valid subspecies on the Atlantic Coast of eastern North America, while in central and western Kentucky and Tennessee, and northern Georgia and Alabama, they behave like valid species." In fact, some authorities consider the scarlet kingsnake the valid species, *L. elapsoides* (Mara 1994, Markel 1990), and it may be the case that in these regions of sympatry this species represents an example of a "Rassenkreis" or Ring Species. A Ring Species may exist when "two reproductively isolated populations, living in the same region, are connected by a geographic ring of populations that can interbreed" (Ridley 1996). Research in progress involving electrophoresis and other molecular/DNA techniques may provide a better understanding of the systematics of this complex (D. Hillis, pers. comm.).

NEW RECORDS

Although there are several records of milk snakes from the Inner Coastal Plain (Western Shore) of Maryland (Harris 1975), few specimens are known from the Outer Coastal Plain (Eastern Shore) on the Delmarva Peninsula. Previously, there were only two specimens known from Delaware (McCauley 1941, Conant 1943), in addition to those from four Maryland localities, three in Worcester County (McCauley 1941, Harris 1975), and one in Somerset County (Grogan 1985). We herein provide 12 new Delmarva Coastal Plain locality records for this species, including individuals from New Castle County, Delaware, and new Maryland county records from Dorchester, Kent and Wicomico counties, as well as additional records from Cecil and Worcester counties (Fig. 1). These new records suggest that this species may be locally common, despite the fact that it is rarely seen above ground due to its secretive, fossorial habits. It is still unknown from the other three counties of Maryland (Caroline, Queen Annes and Talbot) on Delmarva, and there are still no definite records for Kent or Sussex counties in Delaware.

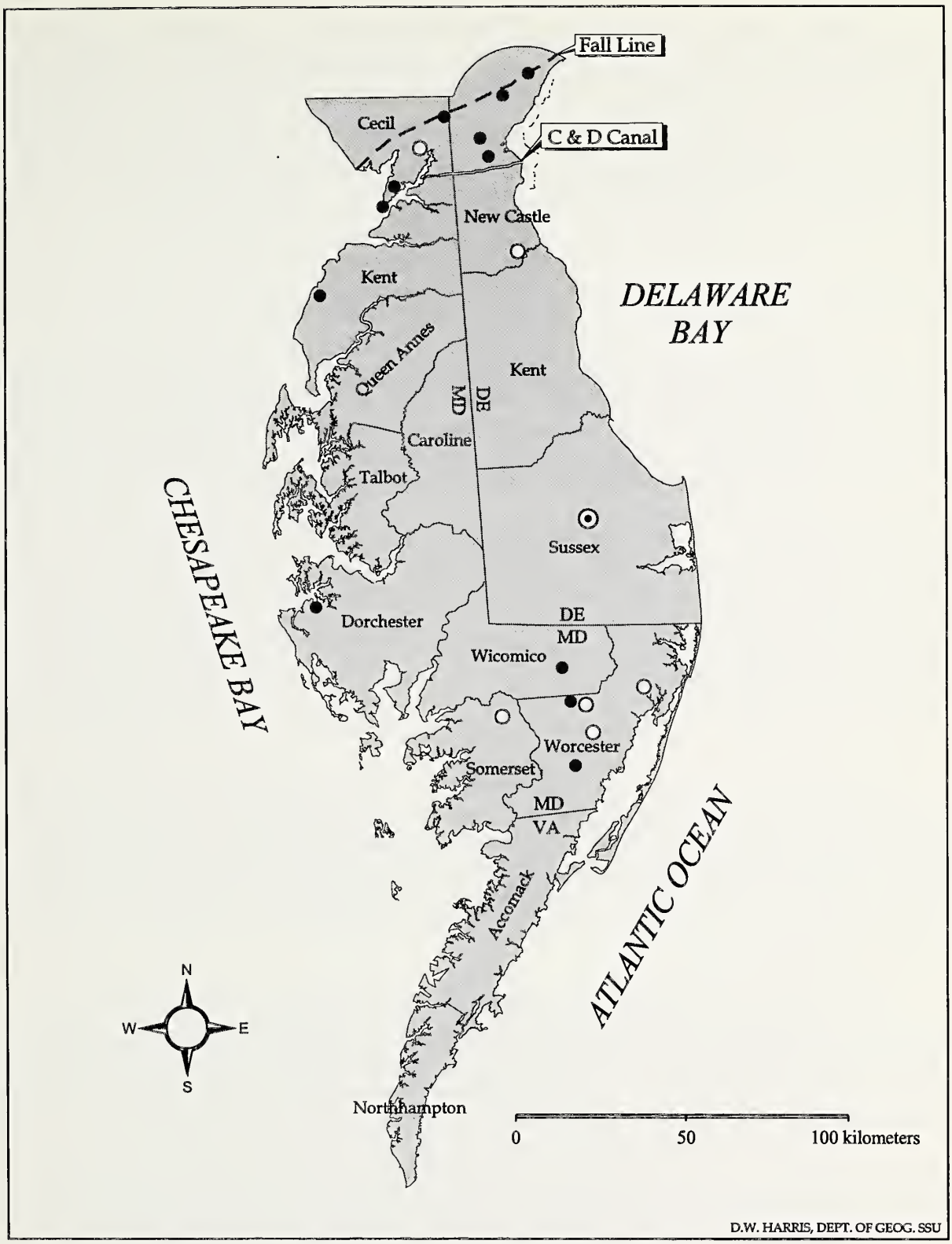

Figure 1. Map showing locality records for *Lampropeltis triangulum* on the Coastal Plain of the Delmarva Peninsula. New records are represented by solid circles, previously published records by open circles. The large open circle with a dark central circle represents the holotype of *L. t. temporalis* from Delaware, locality unknown (after Conant 1943).

Mitchell (1994) noted that there are no substantiated records of this species from the two Delmarva counties of Virginia. He pointed out that although Reed (1957) cited Fowler (1925) when he listed a record from Wallops Island, Accomack County, Fowler did not actually provide a locality for *L. triangulum* for this county. Furthermore, a record plotted by Tobey (1985) from Accomack County, Virginia, is also apparently invalid, as the specimen he based this record on from east of Locustville, supposedly in the USNM, is not present in that collection (J. Mitchell, *in litt.*). Because reliable reports of this species are not available from the Virginia portion of Delmarva, we have not indicated any Virginia records in Figure 1.

DELAWARE

New Castle County

The locality for the holotype (ANSP 3597) of *Lampropeltis triangulum temporalis* was listed by Cope (1893) as Delaware, without a specific location. Conant (1943) referred to this specimen on his map by a half-filled circle in central Sussex County, and we have similarly denoted it by a dark circle surrounded by a large open circle in Figure 1. Conant also showed two localities (as solid circles) from Delaware for two specimens that he considered morphologically identifiable as *L. t. triangulum*. One specimen was from the Piedmont in extreme northern New Castle County, and we have not included it in Fig. 1. The other, a badly flattened DOR specimen found but not saved by Conant on 13 April 1940, 5 km (3 miles) N of Smyrna (locality plotted in Fig. 1), New Castle County, was the only prior record of this species from the Coastal Plain of Delaware in extreme southern New Castle County (R. Conant, *in litt.*). These two Delaware specimens were included in the hatched area on Conant's map that was intended to indicate the general region from which he suggested that intergradation between *triangulum* and *temporalis* occurred. In addition, a paratype of *Lampropeltis elapsoides virginiana* Blanchard (1920), supposedly from Delaware, was considered of questionable origin by both McCauley (1941) and Conant (1943), because it was subsequently discovered to have a duplicate accession number (originally ANSP 3601, now ANSP 21258).

Roger Conant (*in litt.*) has generously supplied us with additional unpublished records of this species from just south of, or on, the Fall Line in New Castle County, as follows (localities plotted in Fig. 1). Alapocas Woods (ca. 61 m), on the Fall Line slope just N of Brandywine Creek and Wilmington, a juvenile found by S. Sanborn 29 July 1948, deposited in Carnegie Museum, Pittsburgh (CMNH 28808). Marshallton (ca. 25 m), 5 km SW of Ellsmere, 6 specimens found near or in home of C. A. Bicking, 8 September 1940 (CMNH 26740-26743), 30 August 1941 (#48127 in Field Museum of Natural History, Chicago), and 22 August 1946 (CMNH 26704).

Recent records of this species obtained from the Delaware Natural Heritage Program include 7 specimens from 5 localities on the Piedmont of New Castle County, Delaware, observed or captured during 1986-88. The following new records are from north of the Chesapeake & Delaware Canal in New Castle County (localities plotted in Fig. 1). A specimen (620 mm total length) in the Delaware Natural Heritage Collection (to be deposited in the Delaware Museum of Natural History, Newark) found on Rt. 71 near Red Lion during ?1987 by J. M. McLaughlin. That individual has 23 body blotches, a broad neck collar, a postocular dark stripe, and grayish ground color laterally that becomes whitish or cream dorsally. An additional specimen was found by McLaughlin on 26 August 1987, 2 km SE of St. George at the Dragon Run Substation dump (5 km SE of the above Red Lion site), and released at the capture site.

MARYLAND

Cecil County

A female in the Delaware Natural Heritage Collection was found by J. M. McLaughlin during May

1978 at Turkey Point on the tip of the Elk Neck Peninsula (locality plotted in Fig. 1). That specimen somewhat resembles *L. t. triangulum* in having 30 body blotches bordered by black, that do not quite extend to the ventrals, a gray ground color, a poorly developed postocular stripe, and a "Y" that is narrowly connected to the head markings on its left branch. Two other specimens were found by visitors to the Rodney Boy Scout Reservation, near the southern end of the Elk Neck peninsula (locality plotted in Fig. 1) during June 1995, and were given to Chris Snow, a counselor there that summer. Snow gave one specimen to the Maryland Department of Natural Resources "Scales and Tales" Program in late 1995, which subsequently died and was not preserved. However, the second, larger specimen is still under Snow's care at the Horsehead Wetlands Center in Grasonville, Maryland, where it continues to thrive on live mice. That specimen has the light gray ground color and a thin postocular stripe typical of *L. t. triangulum*, but it also has a distinct neck collar and 24 reddish-brown body blotches outlined in thin black, and some blotches extend to the ventral scales as in other mid-Atlantic Coastal Plain specimens. Roger Conant (*in litt.*) provided two additional unpublished records from the Rodney Boy Scout Reservation: 9 July 1941, through Charles Gant and C. A. Bicking (CMNH 26755); and 7 August 1957, Jeff Jones, a female of which Conant noted "This specimen although from an area where one would be most apt to expect *triangulum* is very strongly *temporalis*. The collar across the neck is nearly complete although it is notched anteriorly. Several of the dorsal saddles reach downward far enough so that the red pigmentation reaches the tips of the ventral scutes."

Dr. Conant (*in litt.*) provided data on an additional specimen from Cecil Co., a specimen found by Daryl Calder on 24 May 1954, 2.5 km W of Newark, DE, with the following notes "An adult male virtually decapitated. Quite typical of *triangulum*; three rows of spots and belly checkerboard." Interestingly, Harris (1975) assigned all specimens from Cecil County to *L. t. triangulum*, including a locality on the northern base of the Elk Neck peninsula near Elkton on the Coastal Plain (see Fig.1). Harris noted, however, that some specimens collected from along the Fall Line show characteristics of *L. t. temporalis*, which he considered a valid subspecies.

Dorchester County

A juvenile (ca. 375 mm total length) milk snake (Fig. 2a) was found under a piece of sheet metal by Rick Abend on his farm near Madison, Dorchester County (locality plotted in Fig. 1) on 27 June 1992. It was photographed and immediately released. This is a new county record of this species for Dorchester County.

Kent County

Two adult female *L. triangulum* were collected from the Eliason Farm, 3.2 km NNW of the junction of Bayshore Road and County Road 298 at Fairlee, in northwestern Kent County (locality plotted in Fig. 1) on 18 June 1992 and 13 June 1993 by members of Boy Scout Troop 35 (Baltimore Area Council). Because of their significance, they were donated to the Museum of Zoology at Towson University (TU) by Dr. James Hull.

The female found in 1992 had a total length of 601 mm when captured, and survived in captivity at TU until the spring 1998. Her diet in captivity consisted exclusively of neonatal and juvenile mice, and as of October 1997 she had grown to a total length of 652 mm. The pattern of this specimen (Fig. 2b) is clearly different from that of typical *L. t. triangulum* that inhabit the Piedmont of Maryland, Delaware, Pennsylvania and Virginia. There is considerable red on the posterior portion of the head with a typical "*temporalis*" neck collar, and when viewed from above or the side, the dorsal blotches create the appearance of rings by extending onto the ventral scales. The dorsal blotches are reddish brown or "chestnut" colored, bordered by black, and the pale pigmented ground color is distinctly light yellow.

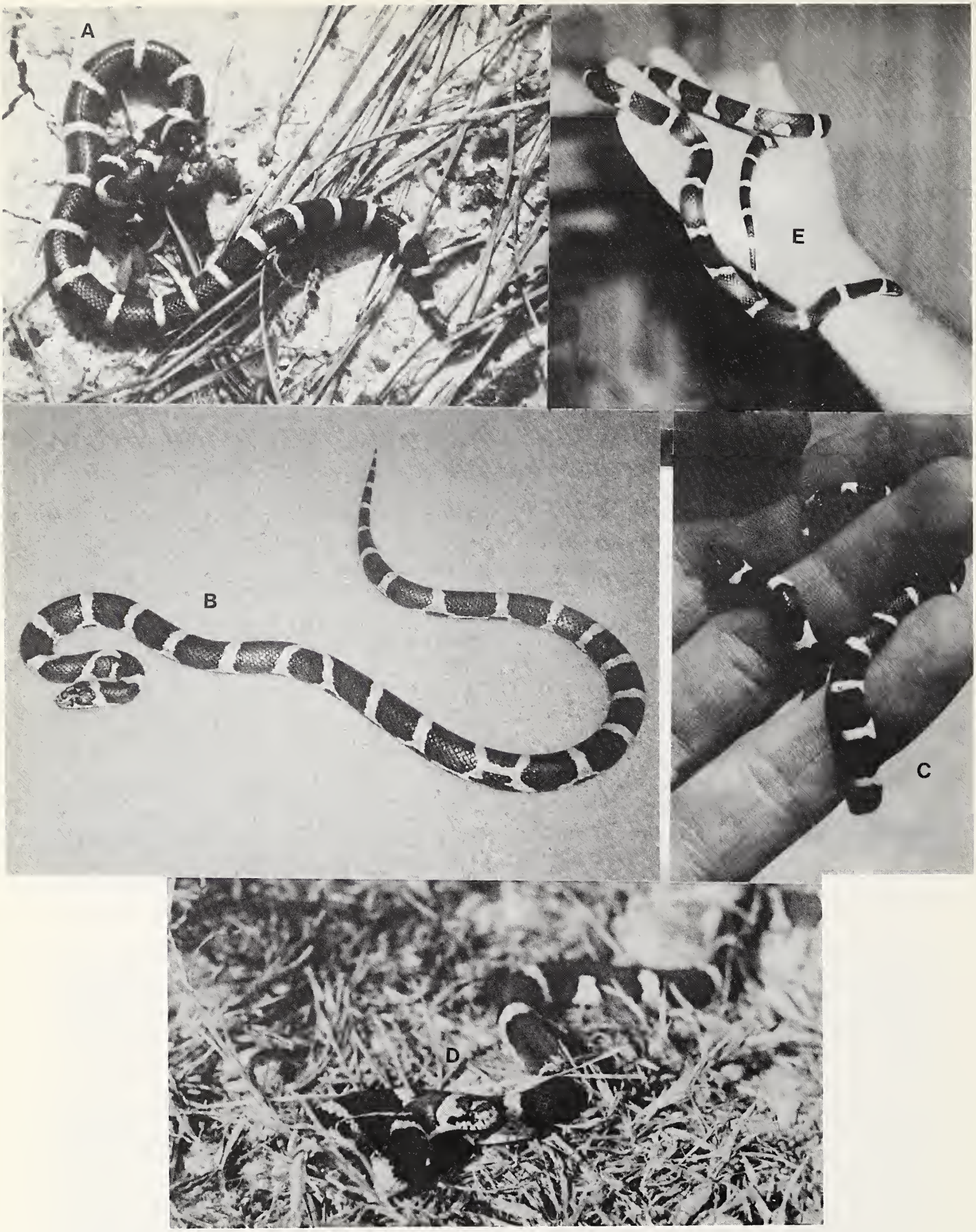

Figure 2. Photographs of *Lampropeltis triangulum* from the Coastal Plain of the Delmarva Peninsula: a, juvenile from Dorchester County, Maryland; b, adult female from Kent County, Maryland; c, juvenile from Wicomico County, Maryland; d, adult from Wicomico County, Maryland; e, adult from Worcester County, Maryland. Photographs by Rick Abend (a), Don Forester (b), and Michael J. Geiger (c, d and e).

The female taken in 1993 was 513 mm in total length when captured, and soon after oviposited 5 eggs, but died two days later. At the time of her death she appeared emaciated, having refused all food items and water offered since her capture. The eggs were maintained in moist vermiculite and all subsequently hatched. Four of the hatchlings were sent to the University of Texas as part of an ongoing molecular investigation of the *L. triangulum* complex being conducted by David Hillis. One hatchling that was retained at TU did not feed and died within five weeks of hatching. It is 175 mm in total length. This is smaller than the 191-197 mm total lengths reported by Miller and Grall (1978) for 5 hatchlings from eggs laid by a female from St. Mary's County, Maryland. That female and one hatchling have been accessioned into the permanent collection of the Towson University Museum of Zoology, and establish a new county record for Kent County. These two specimens have nearly identical patterns, differing only slightly from the specimen found in 1992 in that the ground color is light cream rather than yellow. In both specimens the dorsal blotches continue well onto the ventral scales where they coalesce with ventral blotches, in many instances creating nearly complete body rings.

Wicomico County

A young juvenile (ca. 250 mm total length) male *L. triangulum* was found under a board in Wicomico County by Charles B. Grogan on 30 May 1986, north of the junction of Fooks Road and Twilley Bridge Road, 4 km SE of the Salisbury-Ocean City Airport (locality plotted in Fig. 1). This specimen was kept in captivity for two years and readily consumed lizards (*Scincella lateralis, Eumeces fasciatus*, and small specimens of *Sceloporus undulatus)* but refused all other food items including neonatal mice rubbed with skinks. At preservation (June 1988), it had attained a snout-vent length of 396 mm and total length of 454 mm. This specimen (deposited in the vertebrate collection at Salisbury State University) represents a new Wicomico County record for this species. It has only 19 body blotches, 2 of which are partially subdivided, and red pigmentation that barely extends onto the ventrals on some of the anterior blotches. Two additional specimens found by M. J. Geiger near this same locality, a hatchling (Fig. 2c) taken 15 September 1986 and an adult (Fig. 2d) taken 8 October 1986, were released after being photographed. The specimen in Fig. 2d is unusual in that it is the only individual from the southern portion of the Delmarva peninsula that we have seen with a prominent *triangulum*-like postocular stripe.

Worcester County

A juvenile milk snake was found by M. J. Geiger under debris at Longridge, just W of Md. Rt. 12 off of St. Lukes Road on 26 May 1986, near the locality of a specimen plotted by Harris (1975), and is the 4th record of this species from Worcester County (locality plotted in Fig. 1). The pattern of this specimen (Fig. 2e) more closely resembles that of *L. t. elapsoides* than any other milksnake that we have seen from the Delmarva, in that the dorsum of its head is brilliant red and the bright red body blotches extend considerably onto the ventrals. It is similar to a specimen from Berlin, Worcester County that was illustrated by Conant (1943). It was kept in captivity, and by July 1993 had grown to a total length of 787 mm, just short of the length of the largest Maryland specimen (788 mm) reported by McCauley (1945). A 5th specimen recently found in Worcester Co., a juvenile (total length 380 mm), was taken by M. J. Geiger from under the bark of a stump on 5 May 1996, 5.5 km SW of Snow Hill, on the E side of Rt.113, approximately 1 km NE of Shad Landing State Park (locality plotted in Fig 1).

DISCUSSION

Although Williams (1978, 1988) argued against the validity of *L. t. temporalis*, preferring instead to consider all specimens from the mid-Atlantic Coastal Plain as intergrade *L. t. triangulum* x *elapsoides*, we question the wisdom of this decision. A comparison of specimens from the southern portion of the Inner Coastal Plain of Maryland from Calvert, Charles and St. Mary's Counties in the TU and SSU collections, with those reported herein from east of the Chesapeake Bay on the Delmarva Peninsula, reveals patterns quite different from those of *L. t. triangulum.*

In fact, many specimens from the Delmarva Peninsula clearly resemble specimens from southeastern Virginia and northeastern North Carolina (Conant 1943, McCauley 1941, Mitchell 1994, Palmer and Braswell 1995, Williams 1978 and 1988) in having red blotches that extend onto their ventral scales, and extensive red pigment on their heads (Figs. 2c, e). However, other specimens reported herein from upper (Cecil and Kent Counties, Fig. 2b) and mid Delmarva (Wicomico Co., Fig. 2d) exhibit a variety of head markings and pigmentation while still exhibiting a light neck collar. These latter specimens appear to be somewhat intermediate between those exhibiting a more *elapsoides*-like pattern, and patterns resembling *L. t. triangulum* populations on the Piedmont to the north and west (Ernst and Barbour 1989, Conant 1975).

The herpetofauna of the Delmarva Peninsula has been more or less isolated from adjacent mainland populations since the broadening of the lower Susquehanna River basin due to rising sea levels and subsequent creation of the Chesapeake Bay 10,000 to 15,000 years ago (Lippson 1973). Today, the only terrestrial corridor to this extensive terrestrial ecosystem, a land mass 213 km long and 115 km at its widest point, is from the north via a narrow neck of land less than 25 km wide. We suggest that this natural constriction has served as an effective "genetic bottleneck" (Simpson 1965), acting to slow the invasion of *triangulum* alleles from the north, while promoting the retention of *elapsoides* alleles within populations of milk snakes inhabiting the bulk of the peninsula. Furthermore, most of Delmarva and Maryland's Inner Coastal Plain was connected to southeastern Virginia during the last half-million years of the Pleistocene, when the ancient Susquehanna River channel cut across the Peninsula as far north as southern Sussex Co., Delaware, on its route to the ocean (Colman et al. 1990). This likely explains the very *elapsoides*-like morphology and patterns of milksnakes in this region, and suggests that true intergradation with *L. t. triangulum* along the Fall Line, may be a recent phenomenon.

The potential for genetic mixing has been further impacted by over 200 years of intensive farming which has resulted in significant habitat alteration in this region. The result is that today the Delmarva Peninsula is comprised of a patchwork of small optimal habitats isolated from one another by a suite of natural and man-made barriers. Masters and Forester (reviewed by Forester 1993) used mitochondrial gene fragments to demonstrate that spotted salamander (*Ambystoma maculatum*) populations on the Delmarva Peninsula exhibit significantly less genetic diversity when compared to populations west of the Chesapeake Bay. Furthermore, they discovered that proceeding southward along a north-south transect, populations became fixed for a single genetic haplotype, suggesting the likelihood of reduced gene flow and inbreeding depression in this species.

As noted by McCauley (1941), Williams (1978, 1988) and several other authors, mid-Atlantic Coastal Plain milk snakes inhabit sandy pine-mixed hardwoods, more typical of *L. t. elapsoides* populations farther south than the rocky hardwood uplands preferred by *L. t. triangulum* to the north and west. In addition, their burrowing habits and food preferences (mostly lizards and snakes) are more similar to *elapsoides* than to *L. t. triangulum*, which often bask and usually feed on rodents. Finally, the entire mid-Atlantic population of milk snakes that were considered by Williams (1978, 1988) to be intergrade *L. t. triangulum* x *elapsoides*, suggests a north-south zone of intergradation 500 km wide. More typically, subspecies would be expected to have only a narrow zone of contact over which intergradation might occur (Mayr 1969).

We suggest that Conant's (1943) earlier interpretation of intergrades of *L. t. triangulum* x *temporalis* occurring along the Fall Line from southern New Jersey to northern Virginia may be a more accurate reflection of the situation in nature. It is interesting to note that there are very few records of milksnakes from much of the very broad Piedmont of North Carolina (Palmer and Braswell 1994) and Virginia (Mitchell 1994), a hiatus which appears to effectively isolate eastern milksnake populations in the mountains from Coastal Plain populations in those states. This further supports Cox's (1982) opinion that *L. t. temporalis* occurs throughout the mid-Atlantic Coastal Plain, and that it intergrades with *L. t. triangulum* on the north and west of its range, and on its southern periphery with *L. t. elapsoides*.

Due to the distinct color, morphology, moderate size, and habits that characterize milk snakes indigenous to the mid-Atlantic Coastal Plain, and especially due to the inherent genetic isolation of populations on the Delmarva Peninsula, we suggest that they be recognized as the subspecies, *L. t. temporalis*. At the very least, the distribution of *L. triangulum* on the Delmarva Peninsula represents an excellent model by which to investigate the effects of allele filtration and habitat fragmentation on evolutionary underpinnings of peninsular zoogeography.

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(WLG) Department of Biological Sciences,
Salisbury State University, Salisbury, Maryland 21801.
(DCF) Department of Biological Sciences,
Towson University, Towson, Maryland 21252.

Notes on the Occurrence of the Prairie Warbler (*Dendroica discolor*) in Hickory Point Swamp, Worcester County, Maryland

Christopher M. Heckscher

The Prairie Warbler (*Dendroica discolor*) nests throughout eastern North America from Florida to Maine, typically inhabiting dry brushy clearings or forest edges (e.g., Bull and Farrand 1977, Nolan 1978). Indeed, across Delmarva, this species reliably occupies regenerating clearcuts, young pine plantations, fallow shrubby meadows, and coastal dune-shrub communities.

Because of its presumed preference for dry scrub-shrub environments, this species is not thought of as a warbler associated with forest interior habitat. For example, Bull and Farrand (1977) report, "This species avoids thick woods and has benefitted greatly from the cutting and burning of the forests..." However, Meanley (1979) noted an exception to the common belief that the Prairie Warbler is restricted to dry scrub-shrub reporting that, in the Great Dismal Swamp of Virginia, the Prairie Warbler inhabits dense forest, "...in the same hardwood swamp forest as the Swainson's and Prothonotary Warblers." He then states that, "I have never found the Prairie Warbler elsewhere in the understory of a dense forest." Consequently, this species' affinity for dense palustrine forest in the Great Dismal Swamp has apparently become widely known and has been illustrated as an example of an exception to its more common selection of regenerating forest edges (e. g., Nolan 1978, Dunn and Garrett 1997).

Hickory Point Swamp, a 700 hectare bottomland forest within the floodplain of the Pocomoke River, lies in southern Worcester county, Maryland, approximately 7 km north of the confluence of the Pocomoke River and the Chesapeake Bay. This swamp retains relatively extensive palustrine forests that have been altered by anthropogenic induced activities (timber cutting, fragmentation effects, etc.). However, artificial drainage of Hickory Point Swamp has not occurred to the extent it has in other comparable areas on Delmarva. Additionally, Hickory Point Swamp has been far less studied by ornithologists and its significance as a nesting site for forest-dependent birds has not been thoroughly investigated. This forest may prove to be an important refugium for forest-specialists on Delmarva, especially considering its association with the Pocomoke River, a wetland system locally recognized for its unique avifauna.

On 10 June 1997, while traversing this swamp with a group of naturalists, I noted numerous (> 30) territorial Prairie Warblers singing within dense interior palustrine forest similar to that described by Meanley. This species was abundant in mixed forests of sweet gum (*Liquidambar styraciflua*), black gum (*Nyssa sylvatica*), red maple (*Acer rubrum*), loblolly pine (*Pinus taeda*), pond pine (*Pinus serotina*) and Atlantic white cedar (*Chamaecyparis thyoides*). Canopy height was estimated at 20 to 25 meters and maintained approximately 90 to 100% closure. A dense understory composed largely of sweet bay magnolia (*Magnolia virginiana*), high bush blueberry (*Vaccinium corymbosom*), Virginia willow (*Itea virginica*) and greenbriar (*Smilax laurifolia*), was prevalent in areas where Prairie Warblers occurred. These warblers were not observed as low as the forest shrub-layer, but seemed to sing primarily from the middle and upper sub-canopy.

One of the naturalists present on this field trip, David T. Shoch, noted that the Prairie Warblers we encountered seemed to be in close association with Atlantic white cedar and were apparently absent in the small areas where no cedars occurred. Conversely, no Prairie Warblers were found in the few areas that were dominated only by Atlantic white cedar. Additionally, I noted that Northern Parula (*Parula americana*), which were also common throughout the swamp interior, often were singing in proximity to Prairie Warblers. However, this apparent association with Atlantic white cedar and proximity to singing Northern Parula may indeed be coincidental and deserves further investigation. Due to time constraints and the remoteness of this site, detailed observation of these warblers was not possible in 1997.

Although the Prairie Warbler is a common breeding bird throughout Delmarva, I am unaware of other reports of this species associated with Atlantic white cedar or otherwise occupying dense, mature, palustrine forest. Notable, however, is a report of the Prairie Warbler inhabiting upland forest. Springer and Stewart (1948) reported Prairie warblers in high numbers (48 pairs per 100 acres) occupying an immature loblolly-shortleaf pine (*Pinus echinata*) forest stand in Worcester County, Maryland, approximately 18 km northeast of Hickory Point Swamp.

Why the Prairie Warbler inhabits dense palustrine forest in both the Great Dismal and Hickory Point swamps is not well understood. However, it does appear that this species may be far more adaptable to dense forest than commonly believed. Nolan (1978), in agreement with Meanley, noted that Prairie Warblers may have been present within interior forests of the Great Dismal Swamp since "time immemorial." Indeed, considering these occurrences, it appears possible that the Prairie Warbler may have regularly inhabited the extensive palustrine forests once characteristic of the mid-Atlantic Coastal Plain.

Acknowledgments

Special thanks to William Sipple for organizing and leading the 10 June hike across Hickory Point Swamp. I would also like to thank Karen Bennett, Haven Kolb, William McAvoy, Brooke Meanley, and Chandler Robbins for reviewing this paper. Also, thanks to David Shoch for relaying his observations of the Prairie Warbler mentioned above.

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Delaware Natural Heritage Program
Delaware Division of Fish and Wildlife
4876 Hay Point Landing Road
Smyrna, Delaware 19977
e-mail: checkscher@state.de.us

Additional Atlantic Kemp's Ridley Sea Turtles, *Lepidochelys kempi* (Garman), From the Maryland Portion Of the Chesapeake Bay

Arnold W. Norden and Beth B. Norden

Although the Atlantic Kemp's ridley sea turtle has been known from the Virginia portion of the Chesapeake Bay since 1932, the first Maryland record was not published until almost 25 years later (Reed 1956). Subsequently, Hardy (1962) discussed all of the ridleys known from the Chesapeake Bay, including four dead individuals from Maryland waters in Baltimore City, Calvert and St. Marys Counties. Evans et al. (1997) reported another possible ridley stranded along the Chesapeake Bay near Calvert Beach in Calvert County, Maryland in 1991. The only other published Maryland records for this species were two living individuals taken from a pound net set in the tidal portion of the Pocomoke River in Somerset County, Maryland on 18 June 1997 (Norden, Schofield and Evans 1998).

We are aware of two additional ridleys from Maryland waters. The first of these came to our attention in August of 1979, when Tom Ball reported to us that a large, dead turtle "with flippers" had washed ashore at a private marina, just north of Sandy Point State Park in Anne Arundel County. The shell of that turtle, examined and measured by us, was approximately19 inches (76.2 cm) in length (straight line, not along the curve of the shell). The carcass was slightly discolored and the dermal laminae had loosened (Figure 1a), but otherwise appeared relatively fresh. As Figure 1b shows, that individual was the victim of a boat strike, and the left rear leg and much of the adjacent quadrant of the body had been amputated by the propeller. After being measured and photographed, the carcass was left along the shore.

The other specimen (Figure1c) is at the Calvert Marine Museum in Solomons Island, Maryland. It is represented by a complete carapace, now missing the dorsal laminae, that was found at Calvert Beach in Calvert County, by George and Eleanor Chadwick in 1951 or 1952. It measures (along the curve) 22 and 3/8 inches (570 cm) in length and 21 inches (533 cm) in width. As shown in Figure 1c, this shell exhibits the nearly circular shape characteristic of the Atlantic Kemp's ridley (Carr and Caldwell 1956). The carapace is undamaged and the cause of death is unknown.

Hardy (1962) noted that two of the four Maryland ridleys he reported were then in the collection of the Natural History Society of Maryland. Tim Almaguer kindly searched that collection for us in 1993 and determined that no Atlantic Kemp's ridleys were present. The whereabouts of the specimens reported by Hardy is unknown.

Although relatively few records for *Lepidochelys kempi* are available for the Maryland portion of the Chesapeake Bay, there has been no effort to actually survey the occurrence of sea turtles in Maryland waters, and they may be more abundant than current records indicate. Reports of this species are more common farther south in the Virginia portion of the Chesapeake Bay, where Lutcavage and Musick (1985) recorded 43 *L. kempi* from May 1979 to December 1981. Considering this, Hardy (1962) may have been correct when he suggested that the Chesapeake Bay could be a normal part of the summer feeding range of the Atlantic ridley. This possibility, coupled with the regular occurrence of other species of sea turtles in the middle region of the Chesapeake Bay (Evans et al. 1997), suggests that a specific effort to survey the occurrence of sea turtles in Maryland waters could yield information useful in managing Atlantic sea turtle stocks in general, and the Atlantic Kemp's ridley in particular.

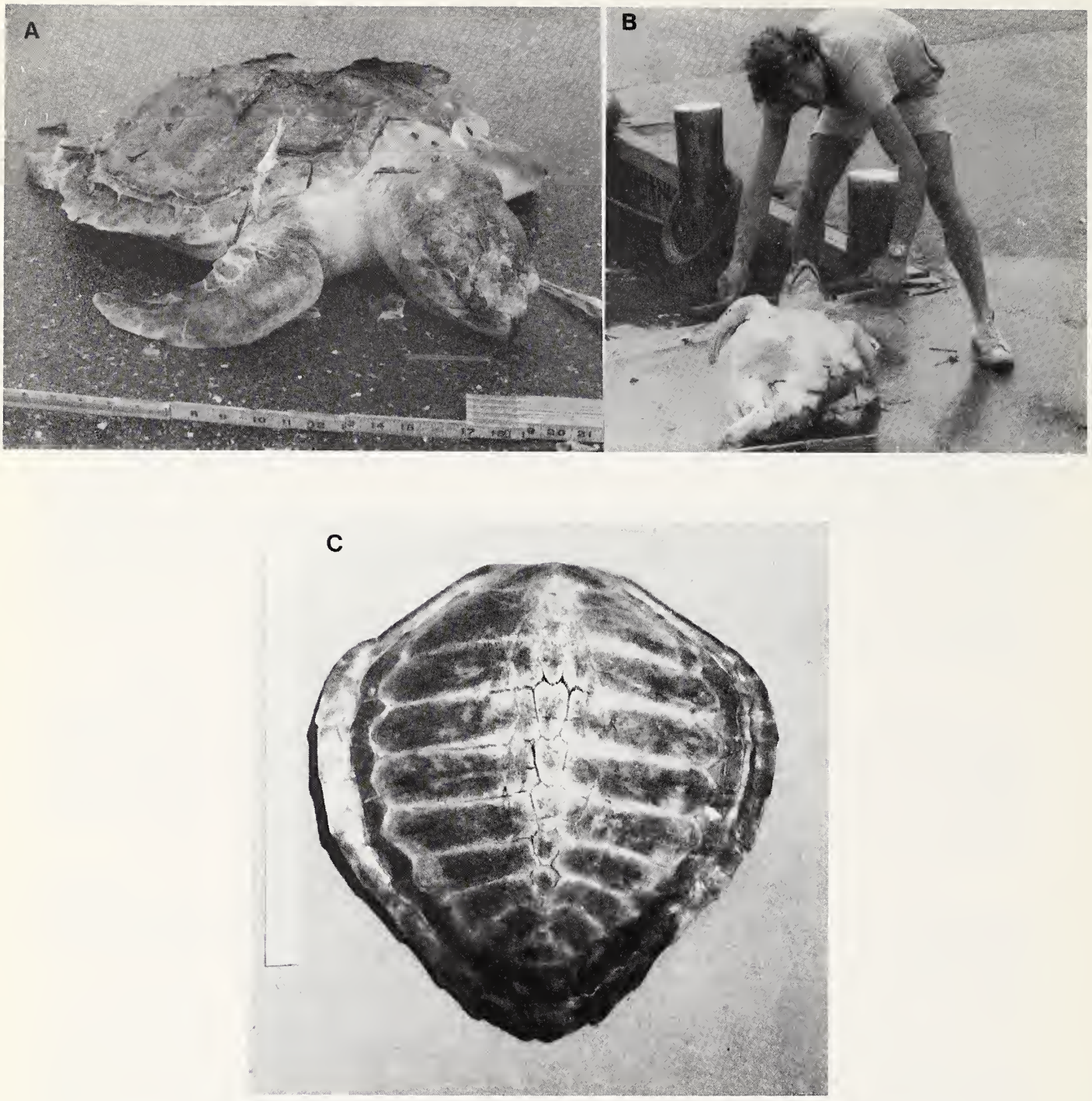

Figure 1. Unreported Atlantic Kemp's ridley sea turtles from the Maryland portion of the Chesapeake Bay. A and B, dorsal and ventral views of turtle stranded north of Sandy Point State Park in 1979. C, dorsal view of carapace found at Calvert Beach in 1951 or 1952.

Acknowledgments

We would like to thank Tim Almaguer for searching the Natural History Society of Maryland for ridleys that were reported to be there. We also thank Tom Ball for bringing the Sandy Point specimen to our attention and arranging for us to have access to it. Dave Bohaska originally showed us the carapace at the

Calvert Marine Museum, and Ken Kaumeyer and the staff at the museum later permitted us to examine and photograph it.

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(AWN) Resource Planning (E-4), Maryland Department of Natural Resources
Tawes State Office Building, Annapolis, Maryland 21401
(BBN) Department of Entomology, National Museum of Natural History
Smithsonian Institution, Washington, DC 20560

Sea Turtle Strandings From Maryland Waters Reported to the National Aquarium in Baltimore, 1990 Through 1997

Arnold W. Norden, T. David Schofield and Joyce J. Evans

Introduction

All of the sea turtles that occur along the Atlantic Coast of North America are protected by the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service. To respond to reports of dead, sick or injured sea turtles, the NMFS established the Sea Turtle Salvage and Stranding Network, a cooperative group of interacting programs involving 18 states along the Atlantic Coast from Maine to Texas. The Maryland Sea Turtle Stranding Network was established in 1990. It includes the Cooperative Oxford Laboratory in Oxford, Maryland, which responds to reports of dead turtles in Maryland waters, and the National Aquarium in Baltimore (NAIB) Marine Animal Rescue Program, which responds to reports of sick or injured turtles.

A synopsis of sea turtle strandings reported to the Cooperative Oxford Laboratory from 1991 through 1995 was given by Evans et al. (1997). They presented data on 92 dead sea turtles of three species (*Caretta caretta, Dermochelys coriacea* and *Lepidochelys kempi*) that were found within the Maryland portion of the Chesapeake Bay or along Maryland's Atlantic Coast during that period. This paper presents information on live sea turtles that were reported to the National Aquarium in Baltimore from 1991 through 1997.

Between 1991 and 1997, the NAIB responded to twenty six reports of sick or injured sea turtles. Most of those turtles were found within its area of operation (Maryland, Delaware and Virginia) but a small number came from other areas along the Atlantic Coast, from South Carolina to Long Island in New York. Twelve turtles were found in Maryland waters. Information on the Maryland turtles is given below.

Caretta caretta (Linnaeus), Atlantic loggerhead

15 June 1991. Ocean City Inlet, Worcester County, Maryland. This turtle was 65 cm in length and weighed 31.5 kg. It was hit by a boat and recovered by the boat's pilot. It was successfully rehabilitated and released in the Atlantic Ocean off Assateague Island.

9 September 1991. Stranded on beach at Assateague Island, Worcester County, Maryland. This turtle was 56.5 cm in length. It was alive when reported, but died before the recovery team arrived. There were no external signs of injury.

3 June 1993. Tangier Sound (Chesapeake Bay) at Deal Island, Somerset County, Maryland. This turtle weighed 16 kg. It was severely wounded by a boat propeller and was later humanely euthanized.

29 September 1993. Mouth of Chester River at Rock Hall, Kent County, Maryland. This turtle weighed 27.2 kg. It had severe head and carapace lacerations suggesting a boat propeller injury. The turtle was covered in mud, and algae was growing within the lesions. Because of the severity of these injuries, the turtle was euthanized.

4 July 1994. Patapsco River at Fort Armistead Park near the Key Bridge, Baltimore City/Anne Arundel County, Maryland. This animal weighed 10.9 kg. The turtle was found floating. It was lethargic, emaciated, and only slightly responsive to stimuli. It exhibited no external signs of injury, but died several days later from a systemic bacterial infection.

27 July 1994. Mouth of Chester River at Kent Island, Queen Annes County, Maryland. This turtle was 46.5 cm in length and weighed 12.3 kg. It exhibited no external signs of injury, but died three days after rescue. The stomach contained a small amount of sand.

8 September 1994. Hatchling (0.015 kg) brought to a local pet store by an unidentified person. It was in poor health and later died.

13 October 1994. Freshwater lake near Clearwater Nature Center, Prince Georges County, Maryland. This turtle weighed 2.5 kg. It died four days after rescue, from fungal pneumonia and exposure to freshwater.

27 May 1995. Mouth of Patuxent River at Solomon's Island, Calvert County, Maryland. This turtle weighed 19.7 kg. Although alive when reported, this turtle was dead when the recovery team arrived. It exhibited no external signs of injury.

Dermochelys coriacea (Linnaeus), Atlantic leatherback

3 July 1993. Tangier Sound (Chesapeake Bay) at Crisfield, Somerset County, Maryland. This large turtle was 190.5 cm (75 in) in length and weighed an estimated 226.8 kg (500 lbs). It was entangled in crab pot fishing gear and was severely injured, with the appendages nearly amputated by the crab pot lines. It was humanely euthanized shortly after arrival at the NAIB and was necropsied at Johns Hopkins University.

Lepidochelys kempi (Garman), Atlantic Kemp's ridley

18 June 1997. Fisherman recovered two *L. kempi* from a pound net in the Pocomoke River, Somerset County, Maryland (Figure 1). Both turtles had ulcerative shell lesions that appeared to be the result of detachment of barnacles and improper transport by the fisherman. Following treatment, one turtle (NAIB9709LK/pit tag # 220733184F) was deemed healthy and released on 17 July 1997. That individual was 35 cm in length (measured along curve of carapace) and weighed 5.2 kg. The second turtle (NAIB9708LK/pit tag # 220F154711) was 35.5 cm in length and weighed 6.6 kg. It was euthanized after several months of treatment for a systematic *Mycobacterium* sp. infection.

Discussion

Two of the records reported above, the loggerheads from the lake in Prince Georges County and the pet store in Baltimore, do not represent natural occurrences. The Prince Georges County turtle was unquestionably taken from a marine habitat and released into the freshwater lake by someone with no knowledge of the biological requirements of this species. There is no indication that the turtle came from elsewhere in Maryland, although that possibility cannot be discounted. It is also unlikely that the hatchling from the pet shop in Baltimore came from Maryland, because no hatchlings have ever been reported in Maryland waters. It was probably brought to Maryland from a location along the southern Atlantic or Gulf Coast where loggerheads regularly nest.

All three species of sea turtles reported here are well documented from Maryland waters (Harris 1975, Evans et al. 1997). Also, the date of occurrence and length of each individual are within the ranges previously reported for these three species in Maryland (Evans et al. 1997).

Two of these loggerhead records represent the northernmost documented reports for the Chesapeake Bay (see Harris 1975 and Evans et al. 1997 for Maryland distribution maps). The northernmost record for

the species within the Bay is the individual found at Rock Hall in Kent County. Harris (1975) did present one report of a loggerhead farther north along the shore of Kent County, but noted that it was based on a sight record of a turtle "tentatively assigned to this species." The second notable northern occurrence was the turtle found in the Patapsco River near Fort Armistead Park. That individual penetrated the Patapsco River to a point less than 12 km from the upper reaches of Baltimore harbor. Sea turtles that travel into these areas are undoubtedly sick or injured; the upper portion of the Chesapeake Bay, with its low salinity, can not be considered part of any sea turtle's normal range.

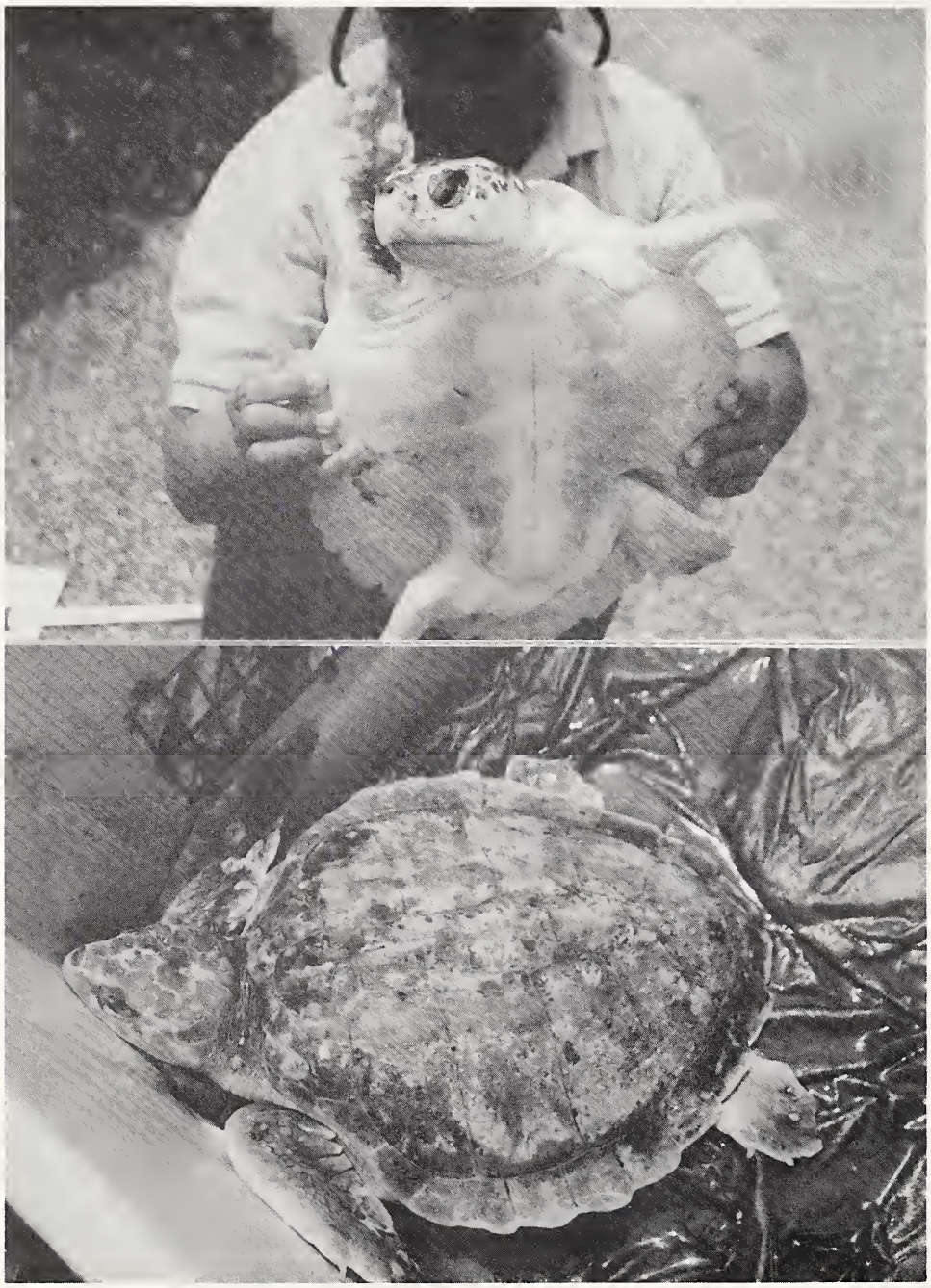

Figure 1. Dorsal and ventral views of *Lepidochelys kempi* taken from pound net in the Pocomoke River, Somerset County, Maryland, on 18 June 1997.

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(AN) Maryland Department of Natural Resources, Resource Planning (E-4)
Tawes State Office Building, Annapolis, Maryland 21401
(TDS) National Aquarium in Baltimore, Pier 3
501 E. Pratt Street, Baltimore, Maryland 21202
(JJE) Cooperative Oxford Laboratory, 904 S. Morris Street
Oxford, Maryland 21654

Floristics Survey of Battle Creek Cypress Swamp Sanctuary, Calvert County, Maryland

Brent W. Steury

Battle Creek Cypress Swamp Sanctuary, located at 38^0 30' north latitude, 76^0 35' west longitude in Calvert County, Maryland, protects 119 acres (48 hectares) of one of the northernmost remaining bald cypress (*Taxodium distichum*) swamps in the United States. The sanctuary lies within the back swamp valley, flat floodplain of Battle Creek and is contained to the east and west by the natural levee borders of the channel. Battle Creek is a tributary of the Patuxent River, flowing southwest from the general vicinity of Prince Frederick. The sanctuary extends along both sides of the creek, upstream and downstream of Maryland Route 506 (Sixes Road).

From May to October of 1997, 18 days of field reconnaissance were conducted in or near the Battle Creek Cypress Swamp Sanctuary. The purpose of this survey was to document occurrences of rare vascular plants. The swamp was originally surveyed by Curran (1907), who reported it to be 93% pure with second growth bald cypress. During the present survey the portion of the swamp traversing the sanctuary was observed to be dominated by a canopy of mature bald cypress, red maple (*Acer rubrum*), and green ash (*Fraxinus pennsylvanica*), which shaded a sparse shrub layer of arrow-wood viburnum (*Viburnum dentatum*), virginia willow (*Itea virginica*), winterberry (*Ilex verticillata*), pawpaw (*Asimina triloba*), and spice-bush (*Lindera benzoin*). The dense herbaceous layer was dominated by lizard's tail (*Saururus cernuus*), orange touch-me-not (*Impatiens capensis*), common woodreed (*Cinna arundinacea*), bur-reed (*Sparganium americanum*), false nettle (*Boehmeria cylindrica*), netted chain-fern (*Woodwardia areolata*), few-bracted beggar-ticks (*Bidens discoidea*), halberd leaved and arrow leaved tearthumb (*Polygonum arifolium* and *P. sagittatum*), and several sedges (*Carex crinita*, *C. frankii*, *C. laevivaginata*, *C. lupulina*, *C. lurida*, *C. radiata*, and *C. tribuloides*). A cardinal flower (*Lobelia cardinalis*) with an albinistic inflorescence was observed on 23 August, 1997.

The sparsely vegetated mud flats along the banks of Battle Creek supported colonies of common water-purslane (*Ludwigia palustris*), water-starwort (*Callitriche heterophylla*), water-mat (*Chrysosplenium americanum*), buttercup-pennywort (*Hydrocotyle ranunculoides*), false pimpernel (*Lindernia dubia*), hedge-hyssop (*Gratiola virginiana*), mud-plantain (*Heteranthera reniformis*), and golden club (*Orontium aquaticum*). Common vines included poison-ivy (*Toxicodendron radicans*) and greenbrier (*Smilax rotundifolia*). The non-native Japanese honeysuckle vine (*Lonicera japonica*) was invasive throughout the sanctuary on wet and dry soils. The uplands surrounding the valley flat were predominately composed of American beech (*Fagus grandifolia*) and oaks (*Quercus alba*, *Q. falcata*, *Q. marilandica*, *Q. prinus*, and *Q. rubra*). Some upland areas within the sanctuary were maintained as managed meadows.

Historically, three state rare vascular plants were known to exist in the sanctuary. Two of these, the purple turtlehead (*Chelone obliqua*) and the leafy pondweed (*Potamogeton foliosus*) were confirmed as extant, while the third species, climbing fern (*Lygodium palmatum*) was not observed (this climbing fern population had dwindled to two plants by 1982 when it was last reported in the sanctuary). As a result of this survey a total of 21 state listed vascular plants have been documented in or near Battle Creek Cypress Swamp Sanctuary. These are listed below, alphabetically by family.

Nomenclature of all taxa follows that of Gleason and Cronquist (1991). Other source books consulted for specimen identification were Brown and Brown (1972, 1984), Fernald (1950), and Radford et al. (1968). State rankings follow the Maryland Natural Heritage Program (1994). Voucher specimens were deposited at the Smithsonian Institution's United States National Herbarium (US), the University of Michigan Herbarium (MICH), the University of Alabama Herbarium (UNA), or the Battle Creek Cypress

Swamp Sanctuary Herbarium (BCSH). All taxa occurred within Battle Creek Cypress Swamp Sanctuary unless noted otherwise.

ALISMATACEAE

Sagittaria australis (J. G. Smith) Small—Appalachian arrow-head. Status Uncertain. *Steury 970708.4* (UNA), 8 July 1997, confirmed by Robert Haynes (UNA). An estimated 200 plants, most in flower and immature fruit, collectively occurred in at least 18 sites on muddy peat in *Taxodium distichum* swamp. This was the only species of *Sagittaria* observed in Battle Creek Cypress Swamp Sanctuary. It is known from only four other sites in two Maryland Counties; Calvert and Harford (Lynn Davidson, pers. comm.). Associates at Battle Creek included *Juncus acuminatus*, *Sparganium americanum*, *Boehmeria cylindrica*, *Leersia oryzoides*, *Saururus cernuus*, *Lobelia cardinalis*, *Alisma subcordatum*, and *Taxodium distichum*.

APIACEAE

Hydrocotyle ranunculoides L. f.—Buttercup-pennywort. Watch List. *Steury 970708.2* (BCSH), 8 July 1997. An estimated 8,000 stems, some in flower and immature fruit, collectively occurred in at least six colonies on mud flats along Battle Creek in *Taxodium distichum* swamp. Associated species included *Chrysosplenium americanum*, *Impatiens capensis*, *Woodwardia areolata*, *Cardamine pensylvanica*, *Viburnum dentatum*, *Ranunculus recurvatus*, *Viola cucullata*, and *Boehmeria cylindrica*.

Hydrocotyle verticillata Thunb.—Whorled pennywort. Watch List. *Steury 970705.1* (BCSH), 5 July 1997. An estimated 200 plants in flower and fruit occurred on saturated organic detritus and muddy peat along a marsh/woodland ecotone just south of Battle Creek Cypress Swamp Sanctuary. Associates were *Samolus floribundus*, *Scirpus americanus*, *Myrica cerifera*, *Cicuta maculata*, *Ptilimnium capillaceum*, *Apios americana*, *Lonicera japonica*, and *Smilax rotundifolia*.

ARISTOLOCHIACEAE

Aristolochia serpentaria L.—Virginia-snakeroot. Watch List. *Steury 970705.2* (US), 5 July 1997. Eight plants in bud occurred on sandy loam covered with leaf litter in shady mixed deciduous woodland just southwest of Battle Creek Cypress Swamp Sanctuary. Associates included *Nyssa sylvatica*, *Polystichum acrostichoides*, *Asplenium platyneuron*, *Polygonum virginianum*, *Arisaema triphyllum*, and *Asimina triloba*.

ASCLEPIADACEAE

Matelea carolinensis (Jacq.) Woodson—Spiny angle-pod. Highly State Rare. *Steury 970823.1* (US), 23 August 1997. Twelve vines, two with immature fruit, occurred along a sandy roadside with deep leaf litter near the entrance to the Battle Creek Cypress Swamp Sanctuary. Associates included *Smilax rotundifolia*, *Campsis radicans*, *Vitis vulpina*, and *Acer rubrum*.

ASTERACEAE

Antennaria solitaria Rydb.—Southern single-headed pussytoes. Highly State Rare. *Steury 970510.4* (US), 10 May 1997. One colony with 32 stoloniferous stems in mature fruit occurred on dry sandy/pebbly loam of an open southwestern slope in shady *Fagus grandifolia* - *Quercus* woodland east of Battle Creek Cypress Swamp Sanctuary. Associates included *Kalmia latifolia*, *Hieracium venosum*, and *Fagus grandifolia*.

Bidens discoidea (T & G.) Britton—Few-bracted beggar-ticks. State Rare - Watch List. *Steury 971004.2* (US), 4 October 1997. An estimated 5,000 plants in flower and mature fruit occurred on muddy peat in *Taxodium distichum* swamp north of Sixes Road in Battle Creek Cypress Swamp Sanctuary. This was the most common *Bidens* observed in the sanctuary. Associates included *Saururus cernuus*, *Impatiens capensis*, *Boehmeria cylindrica*, *Bidens connata*, *Acer rubrum*, and *Taxodium distichum*.

BORAGINACEAE

Myosotis macrosperma Engelm.—Big-seed scorpion-grass. Highly State Rare. *Steury 970510.1* (US), 10 May 1997. Thirty-seven plants in flower and immature fruit occurred on mesic peat hummocks in *Taxodium distichum* swamp within Battle Creek Cypress Swamp Sanctuary, and at least 100 plants occurred on mesic sandy loam in the lower areas of a mixed deciduous woodland just east of the sanctuary. Associates in *Taxodium distichum* swamp included *Acer rubrum*, *Lindera benzoin*, *Arisaema triphyllum*, *Carex radiata*, *Parthenocissus quinquefolia*, *Lonicera japonica*, *Impatiens capensis*, *Claytonia virginica*, and *Ranunculus abortivus*.

CUSCUTACEAE

Cuscuta pentagona Engelm.—Field dodder. Watch List. *Steury 970708.5* (US), 8 July 1997. One colony, in flower and immature fruit, measured 2.3 x 1.5 m in a managed meadow at Battle Creek Cypress Swamp Sanctuary. Parasitic on *Solanum carolinense* and *Ipomoea hederacea*. Other associates included *Rubus pensilvanicus*, *Lonicera japonica*, *Ambrosia artemisiifolia*, *Commelina communis*, and *Campsis radicans*.

CYPERACEAE

Carex cephalophora Muhl. **var.** ***mesochorea*** (Mackenzie) Gleason—Midland sedge. Highly State Rare. *Steury 970802.3* (MICH), 2 August 1997. Annotated as *Carex mesochorea* Mackenzie by Anton Reznicek (MICH) following Kartesz and Kartesz (1980) and state listed as *Carex mesochorea*. Eight plants in mature fruit occurred on mesic sandy loam in a meadow east of Battle Creek Cypress Swamp Sanctuary. A total of four other extant populations are known in Maryland from Caroline, Cecil, Charles, and Montgomery Counties (Lynn Davidson, pers. comm.). Associates included *Verbesina alternifolia*, *Tridens flavus*, *Geum canadense*, *Lonicera japonica*, *Rubus pensilvanicus*, and seedlings of *Liquidambar styraciflua* and *Asimina triloba*.

Carex radiata (Wahlenb.) Small—Stellate or radiate sedge. Highly State Rare. *Steury 970607.3* (MICH), 7 June 1997, confirmed by Anton Reznicek. Approximately 500 fruiting tufts occurred on peat hummocks in *Taxodium distichum* swamp south of Sixes Road in Battle Creek Cypress Swamp Sanctuary. Although historically regarded as rare, recent inventories have found this sedge to be extant statewide (Chris Frye, pers. comm). Associates included *Taxodium distichum*, *Toxicodendron radicans*, *Lindera benzoin*, *Cinna arundinacea*, *Carex laevivaginata*, and *Myosotis macrosperma*.

Carex seorsa Howe—Weak stellate or separated sedge. Watch List. *Steury 970607* (US), 7 June 1997. Two tufts with fruiting stems occurred on a peat hummock in *Taxodium distichum* swamp. Associates included *Acer rubrum*, *Toxicodendron radicans*, *Itea virginica*, and *Ilex verticillata*.

FAGACEAE

Castanea dentata (Marshall) Borkh.—Chestnut. State Rare - Watch List. *Steury 970920.1* (US), 20 September 1997. One 4 m tall tree infected with chestnut blight (*Endothia parasitica*) occurred on sandy loam at the crest of a slope approximately 14 m high along the eastern edge of Battle Creek Cypress

Swamp Sanctuary. Two 8 m tall chestnut trees 5 m distant from the live specimen were still standing but dead due to infestation by the chestnut blight. In 1907, Curran reported that chestnut comprised 26.5 % of the hardwood flora in Calvert County woodlands, with an average of 32 trees per acre. Associates at Battle Creek included *Fagus grandifolia*, *Quercus rubra*, *Kalmia latifolia*, *Asimina triloba*, and *Hamamelis virginiana*.

Castanea pumila (L.) Miller—Chinquapin. Watch List. *Steury 970802.2* (US), 2 August 1997. Four trees, one in immature fruit, occurred at the crest of a sandy loam slope along Battle Creek. Associates included *Vaccinium corymbosum*, *Quercus alba*, *Liquidambar styraciflua*, *Pinus virginiana*, *Liriodendron tulipifera*, *Carpinus caroliniana* and *Sassafras albidum*.

GENTIANACEAE

Bartonia paniculata (Michx.) Muhl.—Screw-stem. Watch List. *Steury 971004.1* (US), 4 October 1997. Nine plants in flower occurred on a moist mat of sphagnum moss on a sandy loam, 1 m high bank slope along a 2 m wide creek in shady deciduous forest, and 5 plants occurred in similar habitat 50 m upstream near the northern edge of Battle Creek Cypress Swamp Sanctuary. Associates included *Viola cucullata*, *Athyrium filix-femina*, *Kalmia latifolia*, and seedlings of *Acer rubrum*.

LILIACEAE

Melanthium virginicum—Virginia bunch-flower. Watch List. *Steury 970816.1* (BCSH), 16 August 1997. Eighteen plants with dehiscent fruit occurred on a moist peat hummock in *Taxodium disticium* swamp. Associates included *Pilea pumila*, *Laportea canadensis*, *Impatiens capensis*, *Cryptotaenia canadensis*, *Cinna arundinacea*, and *Asimina triloba*.

JUNCACEAE

Juncus coriaceus Mackenzie—Leathery or awl-leaved rush. Watch List. *Steury 970823.3* (US), 23 August 1997. Seven tufts with approximately 100 fruiting stems occurred along an edge of *Typha angustifolia* marsh just south of Battle Creek Cypress Swamp Sanctuary. Associates included *Myrica cerifera*, *Hydrocotyle verticillata*, *Cinna arundinacea*, *Sambucus canadensis*, and *Mikania scandens*.

PASSIFLORACEAE

Passiflora lutea L.—Yellow passionflower. Watch List. *Steury 970705.3* (BCSH), 5 July 1997. Two vines with mature fruit occurred on 4 October 1997, climbing shrubs along a fallow cut path along the eastern edge of Battle Creek Cypress Swamp Sanctuary, and 11 vines collectively occurred in two sites in mixed deciduous woodland west of the sanctuary. Associates at the western most site included *Arisaema triphyllum*, *Asimina triloba*, *Nyssa sylvatica*, and *Campsis radicans*.

POTAMOGETONACEAE

Potamogeton foliosus Raf.—Leafy pondweed. Highly State Rare. *Steury 970802.1* (BCSH), 2 August 1997. One colony measuring 0.6 x 0.4 m occurred in Battle Creek under water 0.15 m deep, and was associated with *Sparganium americanum*.

RANUNCULACEAE

Ranunculus pusillus Poiret—Low spearwort. Watch List. *Steury 970510.2* (US), 10 May 1997. Eight plants in flower and immature fruit occurred in a open shrub swamp just east of Battle Creek Cypress Swamp Sanctuary. Associates included *Alnus serrulata*, *Saururus cernuus*, *Viola cucullata*, *Sambucus canadensis*, *Cardamine pensylvanica*, and *Juncus effusus*.

SCROPHULARIACEAE

Chelone obliqua L.—Purple turtlehead. Highly State Rare. *Steury 970823* (MICH), 23 August 1997. An estimated 600 plants occurred on muddy peat in *Taxodium distichum* swamp along the Battle Creek Cypress Swamp Sanctuary boardwalk, and smaller populations were observed scattered throughout the northern half of the sanctuary. The species was observed in flower on 23 August and 4 October 1997 in association with *Taxodium distichum*, *Toxicodendron radicans*, *Itea virginica*, *Viburnum dentatum*, and *Cinna arundinacea*.

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Alice Ferguson Foundation/National Park Service
2001 Bryan Point Road, Accokeek, Maryland, 20607

Reproductive Biology of Three Maryland Populations of *Platanthera grandiflora* (Bigelow) Lindley; a Locally Threatened Species

Thomas J. Stich and Simon Dabydeen

ABSTRACT.- The reproductive biology and abundance of three Frederick County, Maryland populations of *Platanthera grandiflora* (Bigelow) Lindley were investigated during the summers of 1994 and 1995. In1994, 113 plants were observed and 98 (87%) produced 1105 flowers , 668 (60%) of which set fruit. In 1995, 144 plants were observed and 105 (73%) produced 1030 flowers, 248 (24%) of which produced fruits. In 1995, a higher total number of flowering plants produced fewer flowers and exhibited a significantly lower fruit set percentage. Low fruit set percentages could be attributed to an apparent scarcity of pollinators and a high incidence of herbivory. At Gravel Hill Swamp, 22% and 47% of the unprotected population suffered herbivory in 1994 and 1995 respectively, while at Owens Creek, 55% of the unprotected plants were herbivorized in 1995. Flowering plants protected by rabbit fencing were not herbivorized. Factors affecting *Platanthera grandiflora* population dynamics, and conservation strategies are discussed.

Introduction

The Large Purple Fringed orchid, *Platanthera grandiflora* (Bigelow) Lindley, is a terrestrial orchid with a loosely arranged raceme of about 10-60 hermaphroditic flowers characterized by a deeply fringed labellum and a long, slender nectariferous spur (Luer 1975). Flower color ranges from pale lavender to a deep purple. Once considered a variety of *Platanthera psycodes* (L.) Lindley (Correll 1950), *P. grandiflora* received definitive species status based, in part, on differences in column structure and nectary openings (Stoutamire 1974). The color, zygomorphic shape, and deeply fringed labellum of *P. grandiflora* indicate that it is probably pollinated by hawkmoths (van der Pijl and Dodson 1966). Stoutamire (1974) reported that pollinaria are deposited on the compound eyes of hawkmoths visiting the flower. Pollination occurs when, on subsequent visits to flowers, single pollinum or entire pollinarium may be deposited on the column. Numerous seeds, frequently greater than 3,000 for *Platanthera* spp., are produced by each capsular fruit.

In the United States, *P. grandiflora* occurs throughout the Appalachian Mountains from Maine to North Carolina, and west to the upper peninsula of Michigan (Luer 1975). This orchid commonly inhabits cool, wet, neutral, organic soils of upland conifer or northern hardwood forests (Stoutamire 1974). More abundant in the northern part of its range, *P. grandiflora* is considered threatened in Maryland and North Carolina (Gade 1987, Maryland Department of Natural Resources 1991, Weakley 1993). In Maryland, *P. grandiflora* is known to occur in Frederick and Garrett counties, the former having larger populations.

In recent years, Maryland Department of Natural Resources personnel have observed a steady decline in the number of flowering *P. grandiflora* individuals, and have estimated that approximately 400-500 plants are extant in Maryland.

This paper discusses the status and reproductive biology of three populations of *P. grandiflora* in Frederick County, Maryland. Possible conservation measures for this species are also presented.

Materials and Methods

Populations of *P. grandiflora* at three locations (Gravel Hill Swamp, Owens Creek and Straight Creek) were observed, and reproductive censuses were made at weekly intervals from June 10 to August 10, 1994, and from June 9 to July 31, 1995. Data on flowering and fruiting phenology, plant size, population numbers, and indications of herbivory were recorded and analyzed.

At the Gravel Hill Swamp site, rabbit fencing was erected to protect 17 plants in 1994 and 12 in 1995. At the Owens Creek site, all plants were enclosed in 1994 and 42 of 53 plants were enclosed in 1995.

Whenever diurnal site visits were made we attempted to observe visitation of *P. grandiflora* by potential pollinators. In an effort to observe nocturnal pollination events, we visited the Owens Creek site during evening hours (8:00 p.m.-11:00 p.m.) on June 20, 1995.

Results

Population Structure

The *P. grandiflora* population at Gravel Hill grew in a circumneutral swamp at the headwaters of Buzzard Branch, approximately 360 m above sea level. The soil derives its neutrality from the underlying shale and limestone formations (Schmidt 1992). The plants were associated with skunk cabbage, *Symplocarpus foetidus* (L.) Nutt., in a middle-age forest stand that permitted mottled light to reach the forest floor. On drier soils nearby the orchid *Isotria verticillata* (Willd.) Raf. was observed.

In the summer of 1994 and of 1995, the Gravel Hill population consisted of 75 and 91 plants, respectively. The plants were distributed throughout the swamp singly, and in clumps of three to 11 individuals. Vegetative plants appeared predominantly as a single basal leaf, but several had paired basal leaves. Flowering individuals had one or two basal leaves and two to six smaller, bract-like leaves sheathing the axis of the raceme. These ranged from 31-64 cm, and averaged 49 cm tall.

At Owens Creek the population was located in the flood plain on one side of the creek at approximately 430 m above sea level. The plants grew in an area that was logged about 70 years ago. This population had a close association with skunk cabbage and an abundance of the orchid *Galearis spectabilis* (L.) Raf.

In 1994, the Owens Creek population numbered 34 individuals while in 1995, 53 plants were present. Most of the plants were solitary, but several grew in clumps of three to five individuals. The vegetative and flowering plants had attributes similar to those observed at the Gravel Hill Swamp site.

At Straight Creek the population grew along the stream bank in a hemlock, *Tsuga canadensis* (L.) Carr., and pink azalea, *Rhododendron nudiflorum* (L.) Torr., stand. The site had low light intensity due to the dense canopy. Skunk cabbage was absent. Plants of *P. clavellata* (Michx.) Spreng., another terrestrial orchid, were intermingled with *P. grandiflora.*

Phenology

At the Gravel Hill Swamp site, the first floral buds opened on June 14, 1994 and on June 9, 1995. Peak flowering occurred in late June and early July of each year. Floral senescence occurred on August 2 in 1994 and July 31 in 1995. In 1994, 72 of 75 individuals (96% of the population) produced a total of 790 flowers for an average of 11 flowers per raceme. Fifty-seven percent (450) of flowers set fruit for an average of six capsules per raceme. In 1995, 67 of 91 plants (742 of the population) flowered, producing 536 flowers for an average of eight flowers per raceme (Table 1).

At the Owens Creek site, the first floral buds opened on June 7, 1994 and on June 9, 1995. Peak flowering occurred on August 2, 1994 and on July 31, 1995. In 1994, 23 of 34 plants (68% of the population) produced 276 flowers for an average of 12 flowers per raceme, and seventy-one percent (230) of flowers set fruit for an average of ten capsules per raceme. In 1995, 38 of 53 plants (72% of the population) produced 494

flowers for an average of 13 flowers per raceme, and nineteen percent (114) of flowers set fruit for an average of 3 capsules per raceme (Table 1). On June 20, 1995, a red-spotted purple (butterfly)(*Liminitis astyanax* (Fabricius)) was observed visiting several racemes.

Table 1. Size, mean reproductive output, and fruiting efficiency of three *Platanthera grandiflora* populations in Frederick County, Maryland during 1994 and 1995.

Site:	GHS	OC	SC	Total	Change
Total no. plants	75/91	34/53	4/a(16)	113/144	+31(27%)
No. flowering plants	72/67	23/38	3/0	98/105	+7(7%)
% flowering plants	96/74	68/72	75/0	87/73	
No. vegetative plants	3/24	11/15	1/a	15/39	+24(160%)
% vegetative plants	4/26	32/28	25/a	13/27	
Total number flowers	790/536	276/494	39/0	1105/1030	-75(7%)
Mean number of flowers/ raceme	11.0/8.0	12.0/13.0	13.0/0	12/11	
Total number capsules	450/134	230/114	6/0	668/248	-420(68%)
Mean number of capsules/ raceme	6.0/2.0	10.0/3.0	2.0/0	6/3	
Percent fruit set	57/25	71/19	15/0	60/24	

a-all plants (16) were juveniles of either *P. grandiflora* or *P. clavellata.*
GHS = Gravel Hill Swamp, OC = Owens Creek, SC = Straight Creek

At the Straight Creek site, flowers opened on June 21 and senesced on August 9 of 1994. No flowering plants were observed in 1995, but 16 juvenile orchids were present. In 1994, three of four plants (75% of the population) produced 39 flowers for an average of 13 flowers per raceme. Fifteen percent (6) of the flowers set fruit for an average of two capsules per raceme (Table 1).

Pollination

We observed only one possible instance of visitation by a pollinator. On June 20, 1995, a red-spotted purple butterfly, *Liminitis astyanax* (Fabricius), was observed visiting several racemes at the Owens Creek Site.

Herbivory

At the Gravel Hill Swamp site 12 of 55 individuals (22%) of the unprotected 1994 flowering population and 26 of 55 individuals (47%) of the unprotected 1995 flowering population suffered herbivory. None of the 17 and 12 flowering individuals protected in 1994 and 1995 respectively suffered herbivory. At the Owens Creek site, all plants (23) were protected from herbivory in 1994. In 1995, 6 of 11 (55%) of the unprotected flowering plants were herbivorized while all protected plants (27) remained intact. Herbivory did not occur at the Straight Creek site in 1994 and in 1995 (Table 2). Plants were herbivorized during periods of peak flowering, and in most cases only the inflorescences, or portions of them, were consumed.

Table 2. Herbivory of unprotected flowering *Platanthera grandiflora* at three Frederick County, Maryland sites during 1994 and 1995

Site:	Gravel Hill Swamp	Owens Creek	Straight Creek
No. of flowering plants	55/55	0/11	3/0
No. herbivorized	12/26	0/6	0/0
% herbivorized	22/47	0/55	0/0

Discussion

In this investigation of three Frederick County sites, population numbers of *P. grandiflora*, including both flowering and non-flowering plants, increased by 27%, from 113 plants in 1994 to 144 plants in 1995. We suspect that the increase in plant numbers resulted from a reduced deer population. In the severe winter of 1993 - 1994 the high mortality rate of white-tailed deer, *Odocoilus virginicus* (Zimmerman), believed to be the major herbivore of *P. grandiflora*, resulted in reduced herbivory during the 1994 growing season, permitting more plants to thrive, survive winter die-back and become established in 1995.

Although the number of flowering plants increased by 7%, from 98 plants in 1994 to 105 plants in 1995, the total number of flowers produced decreased by 7%, from 1105 in 1994 to 1030 in 1995. A more significant finding involved fruit formation; the overall percent fruit set decreased by 63%, from 668 capsules in 1994 to 248 capsules in 1995 (Table 1). This decrease in reproductive vigor is difficult to explain, but we believe that it could be attributed, at least partly, to a scarcity of appropriate pollinators and increased herbivory. An inadequate number of pollinators would negatively impact fruit production. In this study, we observed only one pollination event. Robertson and Wyatt (1990) indicated that percent fruit set of a

congeneric species, *Platanthera ciliaris,* is pollinator-limited. In studies of other species of terrestrial orchids, percent fruit set was typically low, and often flowering plants produced reduced, below average numbers of flowers (Gregg 1989, Primack and Hall 1990, Zettler and Fairey 1991). Herbivory of flowering plants decreased the number of flowers and/or inflorescences available for pollination and subsequent fruit formation. A significantly higher percentage of *P. grandiflora* plants were herbivorized in 1995 than in 1994 (Table 2), partly explaining the drastic decline in capsule production. The act of herbivory was not witnessed, even though white-tailed deer, *Odocoilus virginicus* (Zimmerman), were frequently observed in the vicinity of our study sites.

As far as we can determine, no statistical data on *P. grandiflora* populations in Maryland have been compiled, and it is, therefore, not possible to evaluate the degree of fluctuation in population numbers in the years previous to this study. Our limited investigation in 1994-1995, indicated an increase in population number in 1995. Yet, unpublished information from Maryland DNR and National Park Service personnel, based on visual estimation of the number of flowering plants over the years, suggests that population numbers for *P. grandiflora* have precipitously declined.

The overall declining trend in numbers of *P. grandiflora* can be attributed to anthropogenic and biogenic factors. Anthropogenic factors include habitat destruction, agricultural practices, and logging (which causes changes in hydrologic relationships that affect the fragile microclimate necessary to maintain the orchid/endophyte symbiosis), pilfering by hobbyists and collectors, and poaching of plants for commercial purposes (Zettler and Fairey 1991). Biogenic factors include herbivory, scarcity or absence of appropriate pollinators, and the absence of a suitable endomycorrhizal fungus necessary to stimulate seed germination.

Many of these factors are currently operating in and around our study sites. In 1994, Jim Voigt, Research Manager of Catoctin Mountain Park, showed us sites where poachers had recently excavated mature flowering plants of *P. grandiflora* and other orchid species.

There are several ways to assure the continued existence of *P. grandiflora* in Maryland. The wire exclosures used in this study were inexpensive, simple to erect, and provided protection from herbivory without impeding pollination. As numbers of *P. grandiflora* decrease, a change in status from "threatened" to "endangered" may be needed to provide a greater degree of protection. To reduce pilfering and poaching, *in vitro* symbiotic seed germination may provide a source of plants for commercial use. Also, seedlings grown *in vitro* could be used to replenish waning natural populations of *P. grandiflora*, as has been done successfully with other terrestrial orchid species (Zettler and McInnis 1992, 1993, 1994). Symbiotic micropropagation of *P. grandiflora*, funded by the American Orchid Society, has been successfully conducted at Frostburg State University by the authors.

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(TJS) American Land Concepts, 238 Main Street
Reisterstown, Maryland 21136
(SD) Biology Department, Nebraska Wesleyan University
Lincoln, Nebraska 68504

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